US Army Corps of Engineers®

Ice Engineering

U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire

Ice Jams in New Hampshire

An ice jam is an accumulation of ice in a river that restricts water flow and may cause backwater that floods low-lying areas upstream from the jam. Areas below the ice jam can also be affected when the jam releases, sending water and ice downstream. Damages resulting from ice jams can affect homes, buildings, roads, and riverine structures; block hydropower and water supply intakes; and decrease downstream discharge (Fig. 1).

Roads may be flooded and closed, or bridges weakened or destroyed, limiting emergency and medical relief to the affected areas. The potential exists for death or serious injury due to jam and flood conditions, as well as during evacuations and other ice mitigation operations. Ice movement and ice jams also can severely erode streambeds and banks, with adverse impacts on fish and wildlife habitat.

Engineers at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) have been working to develop and optimize low-cost structural and nonstructural techniques to prevent or alleviate damages caused by ice jams. Many of these methods, such as early warning systems, ice dusting, ice breaking, ice weakening, and ice jam removal techniques, can be carried out by local agencies at a reasonable cost (Corps of Engineers 1994).

Figure 1. Shear wall left behind following failure of the January 1999 ice jam on the Israel River in Lancaster, New Hampshire. Note ice on low steel of bridge. (Photograph courtesy of www.greatnorthwoods.org.)

The success of ice mitigation efforts depends upon accurate and reliable ice event data for previous ice events that can be used to predict and assess conditions that may increase the probability of an ice jam formation, and to document steps taken by engineers and relief officials in previous years when confronted with ice jam conditions during emergency situations. The CRREL Ice Jam Database was developed to provide a centralized record of ice events, and now contains information on more than 12,200 ice events, with the earliest account dating from 1780.

Database entries include the name of the water body; the city and state where the ice event took place; date of the event, if known; the ice event type, if known; a brief description of damage; the names of CRREL and Corps personnel familiar with the event or site; reference to visual records of the event, if available; latitude and longitude; USGS gage number, if available; and hydrologic unit code.

Records also contain narrative descriptions of ice events (some of which can be several pages) and a list of information sources. There is a separate database entry for each discrete ice event at a given location. Many entries rely on yearly USGS Water Resource Data Reports and other USGS gaging station data. Information also comes from newspapers, books, historical records, and trip reports.

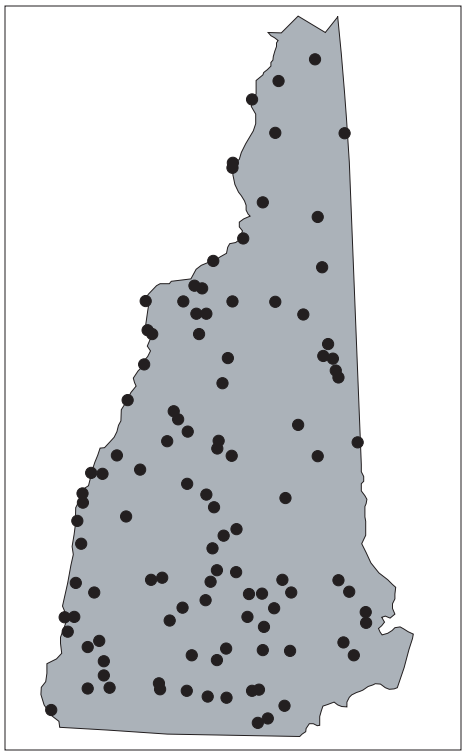

Figure 2. Known ice jam locations in New Hampshire.

This *Ice Engineering Information Exchange Bulletin* provides a brief summary of ice event data within New Hampshire that is contained in the CRREL Ice Jam Database. This is the third in a series that will characterize every state affected by ice jams using the CRREL Ice Jam Database.

New Hampshire ice jams

New Hampshire, one of six New England states, has a population of 1,185,000 and comprises 9,027 square miles of land and 277 square miles of inland water (New Hampshire State Library 2000). As of 1 April 2000 there were 520 New Hampshire ice jam events documented in the CRREL Ice Jam Database (Fig. 2).

The earliest entry in the database for New Hampshire is a January 1835 event on the Contoocook River in Peterborough, during which a general thaw lifted the water level and ice cover above Job Hill Dam, causing the ice to go over the dam. The ice carried away the bridge below the dam and resulted in one death.

The most recent entry is an event that occurred on 24 January 1999, during which 40 senior citizens were evacuated from an assisted living complex in Littleton when water and ice from the Ammonoosuc River surged towards the complex.

About 70% of the information on New Hampshire ice jams came from USGS Water Resources Data. Other sources include newspapers, town histories, CRREL trip reports, Corps of Engineers project reports, and NWS flood statements.

Where do ice jams occur in New Hampshire?

The database contains information on ice jam events at 96 locations on 72 rivers in New Hampshire (Fig. 2). The localities with the most recorded ice jam events are Plymouth/Holderness (40) on the Pemigewasset River, and North Stratford (35) on the Connecticut River. The towns of Goffstown, Groveton, Lancaster, and Etna each have more than 15 recorded events in the Ice Jam Database (Fig. 3). The most ice jams reported for one river occur on the Connecticut River, with 58 events, followed by the Contoocook River with 39, and the Pemigewasset River with 38 events (Fig. 4)

When do ice jams occur in New Hampshire?

The number of ice jams reported varies greatly from year to year, with the highest number (35) recorded in 1992 (Fig. 5). More than 20 events were also noted for 1922, 1968, and 1970.

The number of jams reported in the database for certain years largely depends on the location and availability of records. In 1992, a survey was made of ice-related damage in New Hampshire following a large precipitation event in March that year.

Ice jam occurrence also depends on the time of year; 43% of New Hampshire ice jams have occurred in March and April, when the rivers begin to break up, an indication that these ice jams are largely breakup ice events (Fig. 6). The 47% of jams that occur in January and February could be either freezeup or breakup ice jams.

FEMA Project Impact communities affected by ice jams

Gorham

Although the database has four entries for ice jam events in Gorham, on the Peabody and Moose Rivers, the

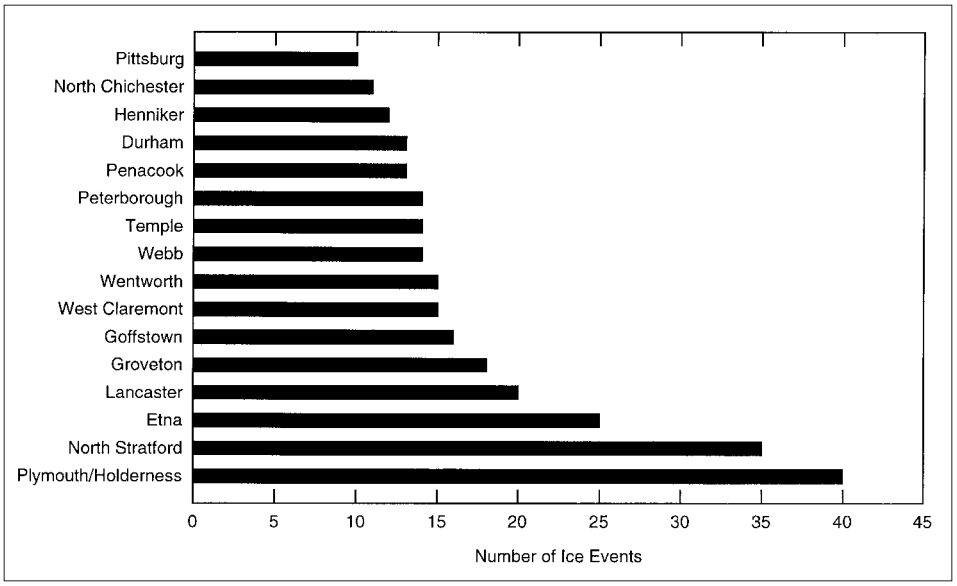

Figure 3. New Hampshire towns with the most reported ice jams.

Federal Emergency Management Agency reports, "Over the past twenty years, there have been a dozen or more significant ice jams." (FEMA 1999) The three documented jams on the Peabody River all occurred at the confluence with the Androscoggin River. These jams have recorded damages in USD of $6K (1992), $17.8K (1982), and $400K (1980).

The ice jam on the Peabody River in February 1982 was particularly destructive to the town of Gorham. Unseasonably warm temperatures led to an ice jam that, combined with a high moisture content in the snow, caused considerable flooding on 4 February 1982. Up to six feet of water covered Hitchcock, Bangor, and Bell Streets. Seven homes were flooded; in five of the homes water filled the basement and flooded the first floor. Evacuations from homes became necessary as the water rose rapidly, surrounding the homes (Currier 1982).

According to the *Berlin Reporter*, Bangor Street resident Nancy Gaboriault had a close encounter during this flood when she went to the river's edge to investigate the jam. As she headed back toward the house, the water came over the riverbank and knocked her down. "My heart was pounding and I was screaming and hyperventilating. I thought I was going to die. … I literally crawled through the water and ice back to the house on my hands and knees, a distance of about 150 to 200 feet. I was screaming, but no one could hear me." Ms. Gaboriault and her family were able to vacate safely just as the house was being surrounded by water (Petrowski 1982).

It took a bulldozer, backhoe, loader, and wood skidder 15 days to cut a 2,500-foot-long channel approximately 50 to 100 feet wide and 10 to 15 feet deep to alleviate the flooding. The bulldozer and backhoe did the majority of work from their own ice roads, which were constructed as they went along (Fig. 7). Total project cost was $17.8K (1982 USD).

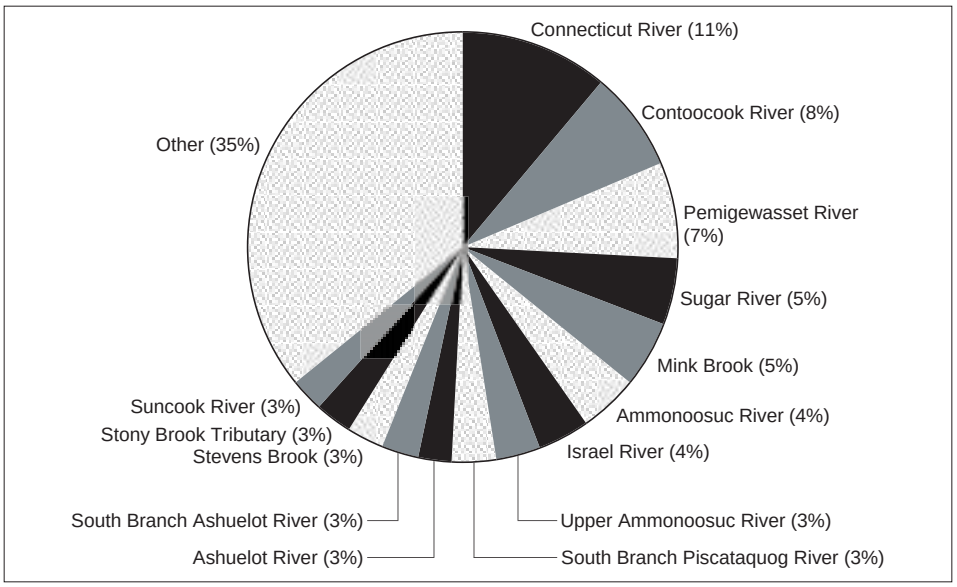

Figure 4. Percentage of known New Hampshire ice jams on specific rivers.

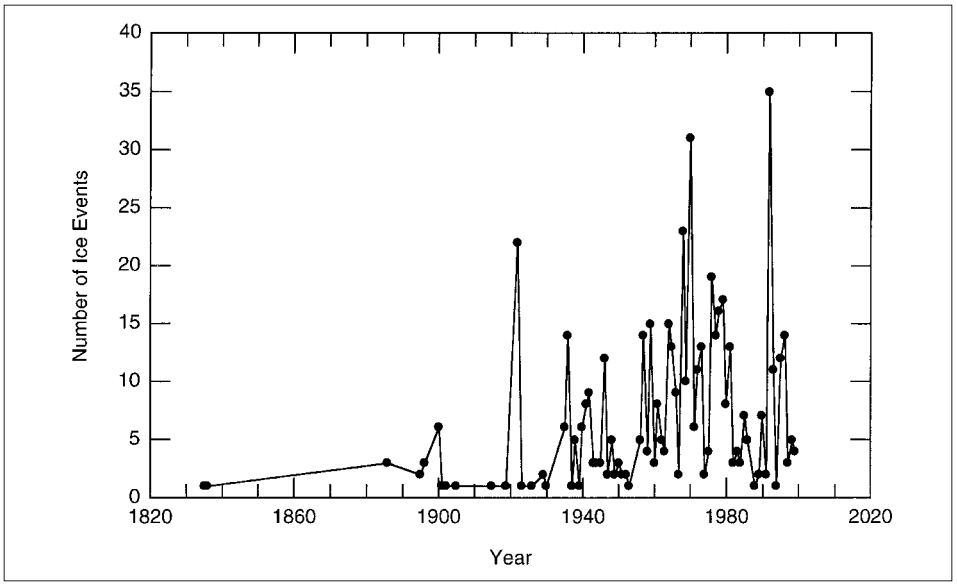

Figure 5. Ice events reported in New Hampshire, 1835–1999.

Peterborough

The Ice Jam Database has 13 ice jam events for Peterborough, on the Nubanusit Brook and the Contoocook River. Recorded damages caused by ice jams in Peterborough have been great throughout history. Several bridges have been damaged or destroyed, and roads, homes, and businesses have been flooded as a result of ice jams.

In March 1936 an ice jam on the Contoocook River caused what is called the worst flood in Peterborough's history. The damages to residential and commercial property were estimated in contemporary USD at between $100,000 and $125,000 (*Peterborough Transcript* 1936).

"The flooding of the rivers broke up the ice which formed gorges [jams] at several points, then broke away, coming down the river in great masses and causing terrific damage." (Corps of Engineers 1974)

A man was rescued from almost certain death on 10 January 1956, while he and a dozen other railroad workers were probing a huge ice jam behind the Summer Street trestle. A

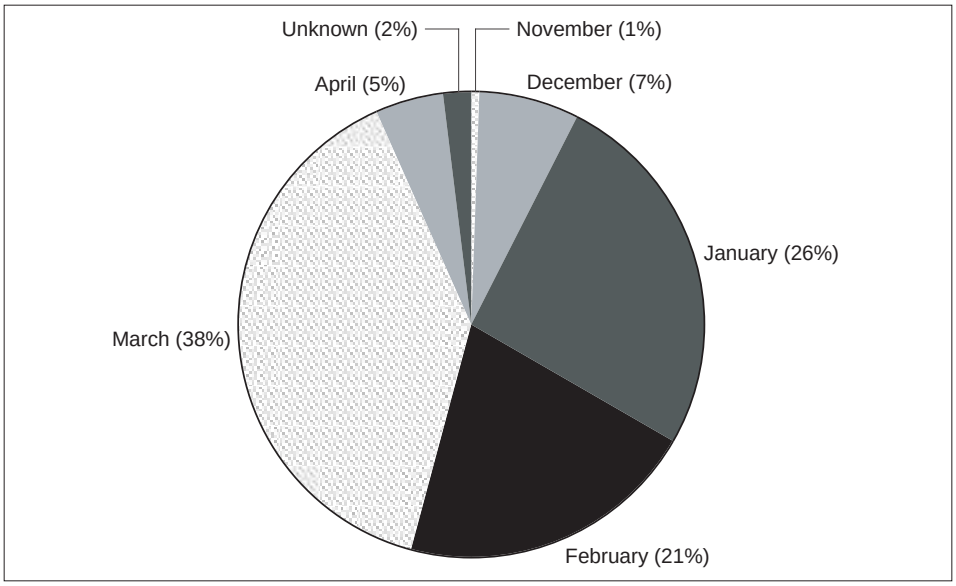

Figure 6. Months for which ice events are reported in New Hampshire.

Figure 7. Backhoe clearing channel in Peabody River, Gorham, New Hampshire, February 1982. (Photograph by Dan Ayer.)

section of riverbank gave way and he plunged into the ice-packed water and disappeared from sight. Co-workers were able to pull him to shore. Minutes later, the entire ice jam was released (*Peterborough Transcript* 1956).

In March 1968, a jam on the Contoocook River caused major flooding in the Peterborough area. The Pack Monadnock Motel had six inches of water in its rooms and several homes on Summer Street were surrounded by water. DPW Superintendent Harry Reed and his Peterborough crew used 20 charges of dynamite to release the jam near the motel. The initial blasts were successful in moving the jam downstream 50 yards, which dropped the water level. "Deputy Fire Chief Larry Bishop, who assisted in the Contoocook dynamite operation, was dunked in the river when he slipped off a cake of ice near the shore. He went in up to his hips." (*Peterborough Transcript* 1968)

Lancaster

The Ice Jam Database contains 20 entries for ice jam events on the Israel River in Lancaster. Eighty-five percent are breakup jams with most (60%) occurring in January and March. Forty percent of the events have known damages, including damage to residential and commercial areas, caused by flooding.

The Israel River has been subject to ice jams with increasing frequency and severity after the failure and removal of four dams on the lower river sometime after they were damaged between the floods of 1936 and 1950 (Axelson 1990). Only two ice jams are noted in the database before 1950. Since 1950 there have been three to five ice jams on the Israel River in Lancaster each decade.

In March 1968, Lancaster was subjected to its worst ice jam flood in history, with a stage at the Main Street Bridge of 866.6 feet MSL. Warm weather and rainfall in March caused the thick ice cover to break up and jam against an earlier jam formed in December. The ice piled against the Main Street Bridge, causing concern for the bridge and surrounding buildings. One hundred and fifty people were evacuated from homes and businesses as water backed up and flooded residential and commercial areas (Perrotta 1968). The Police Station and many businesses near the stream were flooded with seven feet of water (*Manchester Union Leader* 1968). The estimated cost of this destructive ice jam flood was $1.5M (1973 USD).

Plymouth

The Ice Jam Database has 40 ice jam events for Plymouth/Holderness, on the Pemigewasset and Baker Rivers. Forty-five percent of the ice events have occurred during March and April, indicating breakup jams. Twenty-five percent of the records report residential and commercial structure flooding, road flooding, and bridge damage.

On 10 January 1935, the town of Plymouth woke to find the temporary bridge across the Pemigewasset River completely washed out by high water and ice jams. According to the *Plym-*

outh Record, "The piles were broken off like toothpicks before the driving forces of ice, and now there remains nothing but the ends of the bridge, the supporting piles of which are in the solid ground of the banks on either side."

The loss of the bridge was estimated at $4,000 (1935 USD). The road between Plymouth and Rumney (near the Polar Caves) was covered under five feet of water. All traffic was diverted through Quincy (*Plymouth Record* 1935).

During the flood of 10 March 1936, the Plymouth reservoir was washed out, numerous bridges went down, and several hundred people were left homeless. A train bound for Boston was stranded between Plymouth and Ashland as huge cakes of ice covered the track. Eleven freight cars were swept into the river while attempting to rescue the marooned passengers. The Plymouth Fire Department used rowboats to rescue the stranded passengers (*Plymouth Record* 1969). The following week, rain continued to exacerbate the situation, causing open-water flooding that resulted in three-feet-deep water in the railroad station and flooding homes to the second floor (Speare 1963).

Figure 8. Wild Ammonoosuc River between Lisbon and Bath. Note ice in the floodplain and tree scar caused by ice. (Photograph by Kate White.)

Ice jam damages in New Hampshire

As is true for the database as a whole, many of the sources relied upon for information on ice jams in New Hampshire lack quantitative data on damages. However, 82 (16%) of the New Hampshire ice jam events in the database have known damages, a much higher percentage than for the whole database (about 2%). The most common damages include bridge, commercial, and residential damage, road and railroad flooding, evacuations, and agricultural damages. Figure 8 shows an ice-covered floodplain and an ice-damaged tree.

Several deaths resulting from ice jam flooding have occurred in New Hampshire. On 31 January 1835, R.W. Stebbins drowned at the great bridge during a great freshet [jam] on the Contoocook River in Peterborough, and his body was not recovered until the next June (Peterborough undated).

In February 1915, four railroad workers drowned in the Ammonoosuc River while clearing ice from the tracks between Lisbon and Littleton, and ten men were crushed by huge cakes of ice (*Plymouth Record* 1915).

A woman died at the Beauregard Village Trailer Park on the Sugar River in Claremont during 1981 (*Valley News* 1984). The City of Claremont has since received a federal grant to relocate the surviving residents of the trailer park.

The 1936 disaster came in two distinct stages: an ice jam event and an open-water event. The open-water event caused considerably more damage to Plymouth than the ice jam event. For both events, the state's industry netted a total loss of $5,000,000 (1936 USD) in an era when this was a staggering amount (*Plymouth Record* 1969).

Corps of Engineers/State of New Hampshire response

The role of the U.S. Army Corps of Engineers in New Hampshire ice jam flooding has been to provide resources and technical assistance to alleviate flood damage to affected communities. As part of this effort, the Corps sponsored a Section 206 study in which ice-related problems in New England were examined. This study identified 78 New Hampshire communities that have experienced ice jam flooding since 1 January 1970.

The State of New Hampshire Office of Emergency Management sponsored an emergency response workshop presented by CRREL in Hanover, New Hampshire, in 1999. The workshop

was attended by more than 75 local, state, and federal officials, and included discussion of local problem areas.

How is ice jam information helpful?

The Ice Jam Database provides quick access to general information about specific ice jam events, an important feature for those interested in the ice jam flooding history of a certain area. These historical data are crucial during an emergency situation when information about jam locations or stages is needed quickly. Historical information is also important for ice jam mitigation studies at specific sites and necessary in predicting ice jams.

CRREL also has an Ice Jam Archive that contains the hard copies of the NWS reports, newspaper articles, and other reports used as sources for this and other ice-related studies (Herrin and Balch 1995). The information can be checked out or photocopied for research.

Acknowledgments

This study was supported by the New Hampshire Office of Emergency Management and the USACE Civil Works Cold Regions Engineering Program Work Unit *Field Monitoring of Ice Jams*.

Please send any information for inclusion into the Ice Jam Database or Ice Jam Archive to Lourie Herrin, Ice Engineering Research Division, CRREL, 72 Lyme Road, Hanover, NH 03755-1290. Originals can be photocopied or scanned and returned.

The CRREL Ice Jam Database is available via CRREL's Web site (http://www.crrel.usace.army.mil).

References

Axelson, K.D. (1990) Israel River Ice Control Structure Interim Report. Unpublished report prepared for U.S. Army Corps of Engineers New England Division (now District).

Corps of Engineers (1974) Flood plain information: Contoocook River and Nubanusit Brook, Peterborough, New Hampshire. Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

Corps of Engineers (1994) Ice jam flooding: Causes and possible solutions. EP 1110-2-11, U.S. Army Corps of Engineers, Washington, D.C.

Currier, A. (1982) Peabody River overflows. *Berlin Reporter*, 10 February 1982.

FEMA (1999) Project Impact Report (http://www.fema.gov/impact/cities/im_nh05.htm).

Herrin, L.A., and E.M. Balch (1995) Introducing the ice jam archive. U.S. Army Cold Regions Research and Engineering Laboratory, *Ice Engineering Information Exchange Bulletin*, No. 10.

Manchester Union Leader (1968) Lancaster Bridge imperiled, 21 March 1968.

New Hampshire State Library (2000) The New Hampshire Almanac: Fast New Hampshire facts (http://www.state.nh.us/nhinfo/).

Perrotta, F. (1968) North Country is hardest hit by high water. *Manchester Union Leader*, 23 March 1968.

Peterborough (undated) Peterborough, New Hampshire: Town History of Peterborough.

Peterborough Transcript (1936) Contoocook and Nubanusit rise to record height with big property losses, 26 March 1936.

Peterborough Transcript (1956) Railroad workman pulled from river as bank collapses by First National, 12 January 1956.

Peterborough Transcript (1968) Pack Monadnock Motel rooms awash, high water coincides with Great Disaster of March 1936, 21 March 1968.

Petrowski, M. (1982) Victims share feelings. *Berlin Reporter*, 10 February 1982.

Plymouth Record (1915) High waters, 27 February 1915.

Plymouth Record (1935) Plymouth territory threatened by flood as temporary bridge across Pemigewasset swept away by high waters and ice pack, 12 January 1935.

Plymouth Record (1969) Flood headliners of yesteryear, 20 March 1969.

Speare, E.A. (1963) Twenty decades in Plymouth, New Hampshire: 1763–1963. Plymouth, New Hampshire: Bicentennial Commission of Plymouth, New Hampshire.

Valley News (1984) Preliminary evaluation of flooding and flood alleviation along the Sugar River in the vicinity of Beauregard Village, 16 February 1984.

This edition of Ice Engineering *was written by Lourie Herrin, Research Program Assistant; Heidi Eames, Research Assistant; and Kate White, Research Hydraulic Engineer, Ice Engineering Research Division, U.S. Army Cold Regions Research and Engineering Laboratory, Engineer Research and Development Center.*

Editing and layout were done by Gioia Cattabriga, Information Technology Laboratory, Engineer Research and Development Center.

Ice Engineering Information Exchange Bulletin

The *Ice Engineering Information Exchange Bulletin* is published in accordance with AR 25-30 as one of the information exchange functions of the Corps of Engineers. It is primarily intended to be a forum whereby information on ice engineering work done or managed by Corps field offices can be disseminated to other Corps offices, other U.S. Government agencies, and the engineering community in general. The purpose of the *Ice Engineering Information Exchange Bulletin* is information exchange and not the promulgation of Corps policy; thus, guidance on recommended practice in any given area should be sought through appropriate channels or in other documents. This bulletin's contents are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) is part of the Corps of Engineers Engineer Research and Development Center (ERDC).

Communications are welcomed. Write to CRREL, ATTN: J.-C. Tatinclaux (CEERD-RI), 72 Lyme Road, Hanover, NH 03755-1290, or call 603-646-4361.